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Design for Circular Behaviour: Considering Users in a Circular Economy

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Abstract: In a linear economy, a product is manufactured and sold to a customer. Then, little concern is given to what the user actually does with it when they have it. However, in a circular economy where the aim is to circulate products at their highest level of value, the customer's behaviour can become an important part of the system. Circular design strategies have tended to focus on the physical aspects of a product (e.g., disassembly, material selection), but the design of products and services can also have an influence on user behaviour and, to date, this aspect of circular design has not been fully explored. This project aims to define what key user behaviours are required for circular business models to work and to outline how design can enable these 'circular behaviours'. This research project consists of a literature review, case study analysis and expert interviews with practitioners. A theoretical framework for designing products and services to encourage circular behaviour is developed. This work provides an initial step towards a better understanding of the user's role in the transition to a circular economy as well as a preliminary model for how design for behaviour change strategies could be implemented in this context.

Keywords: circular economy; design; business models; behaviour change; circular design; principles of behaviour change; behaviour change wheel; product life extension

1. Introduction

The concept of the circular economy is a vision for how the global economy can operate in a way that is regenerative and restorative by intention and design [1]. It is a collection of a number of different ideas, brought together as a means of reframing the debate around resource use and waste [2]. Based on a 'systems thinking' approach, the aim is to design out waste and other negative externalities, preserve and enhance natural capital and circulate products, components and materials at their highest level of utility and value [3,4].

In addition to the environmental arguments, there is also a strong business rationale for switching to a circular economy. This is in part built on a number of inherent problems in the linear 'take-make-dispose' model of production, including supply and price risks from the extraction of virgin materials, to growing regulatory pressures [5,6]. There are also potential opportunities for businesses to create more value through moving to a circular model, such as through circulating assets for longer and intensifying product use [7,8].

Transitioning to a circular economy relies, in part, on businesses incorporating circular economy principles into their business models [9], thereby radically rethinking how they operate [10]. These principles can be implemented across a number of stages of the product value chain, such as sourcing circular supplies or recovering used resources [11]. Product Service Systems (PSS) are an example of a circular business model which are based on a customer value proposition made up of a mixture of products and services [12]. The ideas being that by shifting profit creation away from

high volume sales and towards providing services, PSS create economic incentives to slow resources and materials flowing through the economy [10,12].

Building on the work of Stahel [13,14] and McDonough & Braungart [15], Bocken et al. [10] outline two fundamental strategies for designing products and business models for a circular economy; slowing of resource loops and closing resource loops. Slowing of resource loops involves increasing the utilisation of products, either through extending product lifetime (through durable design, design for maintenance etc.), as well as increasing utilisation through sharing schemes or PSS. Closing resource loops relates to ensuring that materials can be recycled in a closed-loop fashion at the end of use [10].

Examining these two fundamental design objectives described by Bocken et al. [10], it can be argued that customer behaviour can have an influence over both. When looking at the role of extending product longevity, Cox et al. [16] found that product lifetime depended as much on human factors as it did on functional product durability. The view that users of products drive product lifetimes is supported by many authors (including den Hollander et al. [17]; Van den Berg & Bakker [18]; Mugge et al. [19]). In the context of PSS for a circular economy, Tukker [12] has suggested that people treat products that they do not own with less care, in some cases leading to higher environmental impacts. Customers can also prevent the closing of material loops or cause products to be under-utilised; 'hibernating' their old products by storing them away after they no longer want them [20] or disposing of them in a way which means their material and product value is lost [21]. Bakker et al. [22] (p. 31), summarised the guiding principles of the linear model of production as 'design something, manufacture it as the lowest possible cost, sell it at the highest possible price and forget about it as soon as feasibly possible.'. These objectives change when viewed from the perspective of a circular business model. Here, there is an increased interest in what happens to products once they have left the manufacturer or retailer and a greater focus on getting products or materials back after use so that they can be re-used, remanufactured or recycled. An interesting part of this change, is that with business to consumer (B2C) models, the customer and their behaviour become an integral part of the process. The user of a product and their behaviour can have a significant influence on the overall flow of products, components and materials.

Accenture have stated that the ability of a business to engage and incentivise customers to use and dispose of products correctly is one of the key capabilities of a leading circular company [11]. There is therefore a human element to the circular economy, which is acknowledged, but despite the importance of the role of the 'owner' or 'user' of a product, their part in the circular economy has not yet been clearly described. It has been suggested by a number of authors that designers can play a role in moving towards a circular economy, through their ability to understand and influence business and consumer behaviour [23–25]. Despite this, limited work has gone into equipping designers with the skills needed to understand or encourage these desired behaviours. Therefore, to help to address this gap in the literature, the aim of this paper is twofold:

- to define exactly what user behaviour, if any, is required to enable a transition to a more circular economy;
- to create a framework for designing products and services to encourage desired circular behaviours.

To achieve these aims, first, an extensive review of the relevant literature was conducted to identify user behaviours and design strategies. These were built on by a case study analysis of circular business models for durable consumer goods. Finally, interviews were carried out with circular economy practitioners to confirm, modify and validate the findings. These different strands of research have been synthesised in this paper to build a framework and process for designing for these circular behaviours. This research focuses on durable consumer goods as opposed to fast-moving consumer goods, with the latter designed to have much shorter lifespan and a lower unit cost [26].

2. Background Research

2.1. Design for a Circular Economy

The field of design is acknowledged as one of the key enablers in the transition to a circular economy [5,27]. There is a growing body of research outlining the role of design in a circular economy and suggesting useful frameworks, tools and strategies for implementing circular design principles.

At a product design level, a helpful framework and set of tools for designers to use are presented by Van den Berg & Bakker [18]. This work presents the five most relevant topics in circular product design as: future proof design, design for disassembly, design for maintenance and design for remake and recycling. The first of these, future proofing, is the act of slowing down the flow of products, ensuring they function for longer, as well as being desired and used for longer by their owner. Work by Den Hollander et al. [17] presents a typology of the key concepts of circular product design, which encompasses two main fundamental principles of design for product integrity and design for recycling. The principle of design for product integrity concerns avoiding a product becoming obsolete in the first place, as well designing it so that it can be restored back to its highest level of value. Den Hollander et al. [17] describe a number of design strategies, with much overlap with that of Van den Berg & Bakker, such as designing for durability (emotional and physical), designing for maintenance and upgrading, and design for remake and repair.

Moreno et al. [28] have also produced a conceptual framework for circular design, building on Design for Sustainability approaches. This work takes a much broader view of design, ranging from product level approaches, to more systems level design. Like with previous examples, design for repair, refurbishment, maintenance and reuse are presented, along with design for easy end-of-life cleaning, collection and transportation of recovered material/resources. This framework also brings in considerations around circular materials supplies, whole system design and resource conservation.

All the frameworks outlined above, as well as others in the literature [10,22], acknowledge in some way that users have a role to play in extending product life. This is suggested explicitly, with strategies such as design for attachment and trust [22,28] or emotional durability [17]. It may also be implied with strategies such as design for maintenance or repair. If it is assumed that these roles are the responsibility of the user of products—there seems to be less consideration that these tasks also have a human component, as well as physical, and consideration needs to be given to the incentive for performing these jobs.

The term design itself, is a broad word covering a wide range of activities. The Design Council, UK, views design as a discipline, which is spread across a spectrum. At one end is technical design, where the process is around the design and specification of an item, component or system, at the other is human-centred design, where the process of design starts with understanding people and creating solutions for their needs [29]. The majority of the current literature above on circular design focuses on the technical side of this spectrum. However, products should not only be designed with a focus on how design principles allow products to fit within in a circular economy system, but also with how products fit within people's needs, desires and patterns of behaviour. Arguably, there is a need to further explore the role human centred design can play in the circular economy.

A step in this direction is made by The Circular Design Guide, produced through a collaboration between the Ellen MacArthur Foundation and IDEO, which provides methods and mind-sets to help designers apply design thinking and circular design [30]. These tools incorporate more human-centred thinking into the design of circular products and services, encouraging designers to appreciate how the user fits within the system. The Circular Design Guide is a useful contribution for appreciating that the user is a key part of the circular economy system and encourages designers to think about how the design of products, services and systems might influence their behaviour. However, it does not specifically define the desired role, if any, of the user in a circular economy or propose a structured approach for designing towards this behaviour.

It can be argued that much of the research in design for a circular economy, to date, addresses the question: 'how can the design of products help enable a circular economy?' However, it would be also helpful to ask the question: 'what is the user required to do to enable a circular economy?' Which naturally leads on to a design question of: 'How can the design of products and systems encourage or enable users to behave in this way?'

2.2. Design for Behaviour Change

Design for behaviour change (DfBC) is an area of design intended to influence or result in certain user behaviour. DfBC techniques have been applied in a number of sustainable and social contexts, from reducing user's product energy consumption [31,32] to avoiding littering [33]. This section provides a brief summary of relevant DfBC work, an in-depth review of specific models is included in the findings.

The idea that people's behaviour can be influenced by product design is not new. Although not explicitly aiming to change user's behaviour, Norman [34] described how perceived affordances in products can influence how people interact with them. When creating products, designers are to some degree, intentionally or not, shaping user behaviour [35]. The basis of design for behaviour change (DfBC) is that by considering this use phase of products, designers have an opportunity to influence consumers' behaviour and therefore reduce negative externalities [36].

DfBC strategies have the potential to assist the transition to more circular business models through encouraging customers to engage with products in a way which contributes towards the design aims of slowing and closing resource loops. However, these techniques have not been explored in the context of the circular economy, particularly in the context of how behaviour assists circular business models.

It is also important to highlight that a key principle of a circular economy is to drive system wide change [4], whereas previous work in Design for Sustainable Behaviour (DfSB) has focused mainly at a product or individual level change [37]. The application in this paper is to understand how design to encourage more circular behaviour at an individual level can help as part of a wider system transition. Although crucially, as noted by Selvefors et al. [38], it is not possible to design behaviour, it is only possible to design the preconditions which define how somebody may behave. Meaning that behaviour change alone is not a reliable enough method as the only route to system change.

2.3. Phases of Influence

The customer's engagement with a product can be simplified into three main phases: (a) the point of acquiring the product (through purchase or engagement in the business model); (b) the main use phase; and finally; (c) end of use, where the customer may give the product back to manufacturer, keep it, pass it on or dispose of it otherwise. Although it has been argued that this stage-gated view of use is not in line with a customer's more complex view on ownership [39], it is a helpful distinction in this case. The boundaries of this customer use phase are defined by the associated business model. Using design for behaviour change principles, the product itself can potentially influence the customer's behaviour during the use and end of use phases (b and c).

The purchase, or engagement phase (a), is also an area which some argue needs to be explored in terms of behaviour change [25]. There are a number of apparent barriers in customer behaviour, which may make a transition to more circular models difficult such as: a lack of acceptance of novel business models [40], a need for ownership [41], or perceiving reused products as contaminated [42]. However, these topics are outside the scope of this project, which will focus on the latter two phases.

3. Methods and Concept of the Study

The aim of the research was to develop a framework for designing products and services to encourage desired circular behaviours. As discussed, understanding the importance of customer's behaviour's role in the development of circular business models has not previously been explored in a joined up way. Therefore, an explorative research approach was needed.

Figure 1 shows an overview of the iterative research process which was used to build the framework, the output of which is a description of desired circular behaviours as well as strategies for encouraging this behaviour. Both components were developed through a literature review, case study analysis and practitioner interviews.

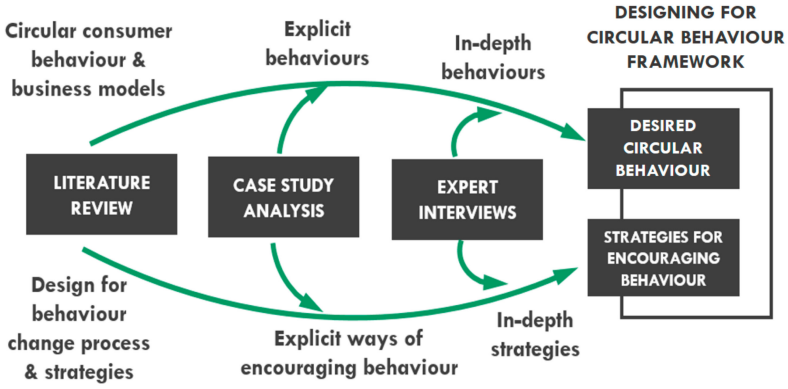

Figure 1. Research approach for building the framework.

Stage 1: Literature review

The first stage of the research was an extended literature review, focused on understanding how design for behaviour change strategies could be employed through both a product and aspects of a business model. DfBC literature was reviewed to understand the most applicable strategies for influencing behaviour and how these strategies could be built into a circular design process.

On top of the specific behaviour change research. The literature contributed to forming the model of desired circular behaviour by building a categorisation of B2C business models, as well as an understanding of how user behaviour influences a circular economy.

Stage 2: Case study analysis

The second stage was a case study analysis of different circular business model archetypes to form a basic model for circular behaviour, as well as insight into the approaches that companies use to encourage this customer behaviour. Case study analysis is a suitable research method for investigating contemporary phenomenon in a real life context and is suitable for exploratory work [43]. Eight case studies were selected for study. As stated previously, business models are seen as a key enabler of a!circular economy. PSS define the consumer experience and involvement; therefore, cases were chosen that: (i) adopted a B2C business model and (ii) were within the consumer goods sector. Cases were chosen which represented all of the three selected PSS business models categorised by Tukker [12] as:

- product-orientated: profit based on selling products, but with supporting services. Similar to the 'Classic long life model' outlined by Bakker et al. [22].
- use-orientated: the actual product still plays a key role to the value proposition, except ownership is with the service provider. Also known as 'The Access Model' [22].
- results-orientated: the value proposition is based on an actual result or required task, not on a specific product.

The case studies were taken from the Ellen MacArthur Foundation case study library, or found in circular economy literature, and were built on through information on company websites and additional literature. The list of case studies for each business model archetype is shown in Table 1.

The results of the analysis were categorised according to business model archetype in Table 1 and phase of users influence on product that this research is focusing on (e.g., during use or end of use). Each was analysed for the required user behaviour and how the business had sought to achieve this behaviour.

Table 1. Case Studies according to business model archetype.

Business Model Archetype	Case Study Example	Sources
Product Orientated	Patagonia	[26,44]
	Vitsoe	[22,44]
	Agency of Design	[45]
Use Orientated	Mud Jeans	[46]
	Toronto Tool Library	[47,48]
	Gerrard Street	[49]
Performance Orientated	Bundles	[50]
	BMW Drive Now	[51]

Stage 3: Expert Interviews

The Case study analysis provided high level detail of explicit user behaviours and strategies that companies had adopted to encourage them, for example; damaging products will result in charges. In stage 3 this initial model was iteratively improved through the use of expert interviews with circular economy practitioners. This stage provided a more in-depth understanding of both desired customer behaviours, as well as strategies for encouraging these actions. Practitioners were selected based on having experience with one, or a range, of the selected circular business model categories. Their role or experience and their organisation is shown in Table 2.

Table 2. Circular economy practitioner interviewees.

Role/Experience	Organisation
Circular Economy Design Strategist	Philips
Managing Director	Vitsoe
Circular Economy Portfolio Director	IDEO
Partner—Circular Business	QSA Partners
Design Consultant	Freelance/Department 22

Interviews were semi-structured and lasted between 30–45 min. These focused on four main topics: desired behaviours (if any) which helped circular business models to function, user behaviours which made circular business models more difficult, strategies used to encourage desired behaviours and a review of the preliminary model.

Interviews were then coded through a concept driven approach, where the key thematic ideas found through the literature review and case study analysis were used as the basis for coding [52].

Stage 4: Synthesis and interpretation

The three iterative stages of: literature review, case study analysis and practitioner interviews were then synthesised to form two outputs. The first of these outputs is the model of circular behaviour (Section 6), which describes the desired user behaviours for operating circular business models. The second output is the description of a process for designing for circular behaviours (Section 7), which is developed based on design for behaviour change literature (Section 4), as well as findings from the case study analysis and interviews on how businesses currently aim to encourage behaviour (Section 5).

4. Findings: Literature Review

Fundamentally, Niederer et al. [53] argue that there are four basic approaches to changing behaviour:

- Making a desired behaviour easier for a user to do,
- Making an undesired behaviour harder to do,

- Trying to get users to want to perform a particular behaviour,
- Trying to decrease user's inclination to perform a particular behaviour.

There are many different models of human behaviour and behaviour change, and therefore a wide variety of strategies for trying to change behaviour. In the field of design for sustainable behaviour (DfSB), the main focus is to understand how an artefact, or product, can be used to influence behaviour [36,54,55]. However, it may also be useful for a business or service provider to understand how elements of their wider business model can also encourage desired behaviours from customers. It is therefore valuable to understand how both product-led and more general design interventions can be employed

4.1. Physical and Digital Product Strategies

Many authors agree that product-led DfBC strategies sit along an axis; at one end, the user is in control of decision making, at the other, the product has control [31,36,56–58]. Based on previous literature, Zachrisson & Boks [58] produced a scale describing this distribution of control between user and product. At the user end of the scale, information or feedback requires the user to register, interpret, understand and reason, requiring more effort, whereas at the product control end, the tasks are done automatically [58]. Despite not detailing specific strategies, this scale provides a useful framework for picturing where potential interventions sit and according to Boks, Lilley, & Pettersen [59], this is the preferred taxonomy amongst practitioners.

Tromp et al. [60], argue that the choice of intervention should also be based upon intended user experience. Looking at the wider context of design for social responsibility, Tromp et al., state that behaviour change interventions should address 'collective concerns' (the social/environmental issues aiming to be resolved) in the context of the individual concerns of the user. Therefore, how the user experiences the intervention and how this aligns with their personal desires and beliefs, determines its effectiveness in changing their behaviour. This may be specifically important when designing circular business model offerings, in particular PSS, as Tukker, [12] has suggested that customers do not like the idea that their use of products is prescribed. To account for this, Daae et al. [61] present a second axis for how obtrusive, or how aware the user is of the design intervention. These two axis of product/user control and obtrusiveness, create the potential landscape for product design strategies.

It is acknowledged that it can be difficult for designers to know where to position and apply different behaviour change interventions [53]. Daae et al. [61], have outlined a tool called Principles of Behaviour Change. Based on behavioural psychology, the tool aims to inform designing for behaviour change, by indicating which design interventions are likely to be most effective, based on user's behaviour, intentions and habits. The Principles of Behaviour Change tool is effective in assisting with the selection and design of product strategies. However, the tool is limited in that it is not able to consider a wider array of potential business interventions.

Beyond the physical aspects of product design, digital strategies, typically through a mobile device are also seen as effective in changing behaviour. Embedded data collection and connectivity are enabling technologies which can help contextualise and respond to user behaviour [56]. The ability for the user to control their surroundings via a hand-held device can shape the context in which decisions are made, in some cases drastically reducing the effort needed for a given action [62]. For example, an app might make selling old furniture easier than taking it to a local household waste site and therefore more likely.

4.2. Wider Business Strategies

Another prevalent model of designing behaviour change interventions is the Behaviour Change Wheel [63]. The Behaviour Change Wheel is based on the COM-B model, which is built on a review of 19 different frameworks of behaviour. COM-B, signifies the factors driving behaviour; Capability (Physical and Psychological), Opportunity (Social and Physical) and Motivation (Automatic and Reflective). The COM-B model of behaviour is useful in that it is comprehensive,

incorporating both user agentive and contextual influences [53]. It also helps to link promising intervention functions to the different components of behaviour [64]. The behaviour change wheel has been applied in a number of case studies, primarily in the field of health and medicine [64].

Once behaviour is understood according to the COM-B model, promising intervention functions are then highlighted. Table 3 shows a classification of the main interventions functions—the way interventions aim to change behaviour, according to Michie et al. [64].

Table 3. BCW Intervention functions according to Michie et al. [64].

Intervention Function	Definition
Education	Increasing knowledge or understanding
Persuasion	Using communication to induce positive or negative feelings or stimulate action
Incentivisation	Creating an expectation of reward
Coercion	Creating an expectation of punishment or cost
Training	Imparting Skills
Restriction	Using rules to reduce opportunity to engage in the target behaviour
Environmental restructuring	Changing the physical or social context
Modelling	Providing an example for people to aspire to or imitate
Enablement	Increasing means/reducing barriers to increase capability (beyond education) or opportunity (beyond environmental restructuring)

The integration of the behaviour change wheel, understanding user's behaviour according to the COM-B model and the Principles of Behaviour Change approach, provides a more encompassing and structured method to highlighting potentially effective solutions which can be implemented across product design, as well as in the wider business.

5. Findings: Case Studies and Practitioner Interviews

5.1. Desired Circular Behaviour

Initially, the case study analysis was based on the three business model archetypes described in Section 3: product-orientated, use-orientated and results-orientated. However, through the analysis it was difficult to distinguish a core difference in the desired user behaviour between the use and result oriented PSS. The categorisation was therefore refined to reflect the key differentiating factor, which was ownership. In product-based business models, ownership is with the customer [12] and they therefore have ultimate control with what they do with the product. When ownership is with the provider, as is the case with use and results-orientated PSS, the business has more interest invested in the goods and contractual obligations tend to dictate the movement of products.

The case studies and interviews were thematically analysed for behaviours desired from users of each business model archetype. Appendix A shows each of the descriptive codes identified through the research, each of these is represented with an example from either a case study or interview quote.

5.2. Strategies for Encouraging Behaviour

The case studies and interviews were coded through a concept driven approach, according to the Behaviour Change Wheel intervention functions [64], shown previously in Table 3. Appendix B shows coding examples for each intervention function. Incentivisation, as an intervention function, was separated into either financial or the provision of value in another form. The reason for this is that this has wider implications for a business model and strategy.

6. Synthesis and Interpretation

The findings from the literature review, case studies and interviews were triangulated, with the identified descriptive codes built up into 18 key themes, to form a description of the desired circular behaviours, as well as understand strategies for how business organisations could encourage certain behaviours through their business model.

6.1. Desired Circular Behaviours

The aim of the model of desired circular behaviour is to act as a guide for designers to understand what the key user behaviours that help circular business models to function are and therefore design products, services and other systems with these in mind. The model is not prescriptive and different behaviours will not be relevant for various product categories or business models, it simply highlights the categories of behaviours which may be relevant.

The model of circular behaviour is shown in Figure 2, separated into the use and end of use phases. These behavioural groups were identified through the analysis of the case studies and interviews, through a thematic coding process. Each group is described in detail below.

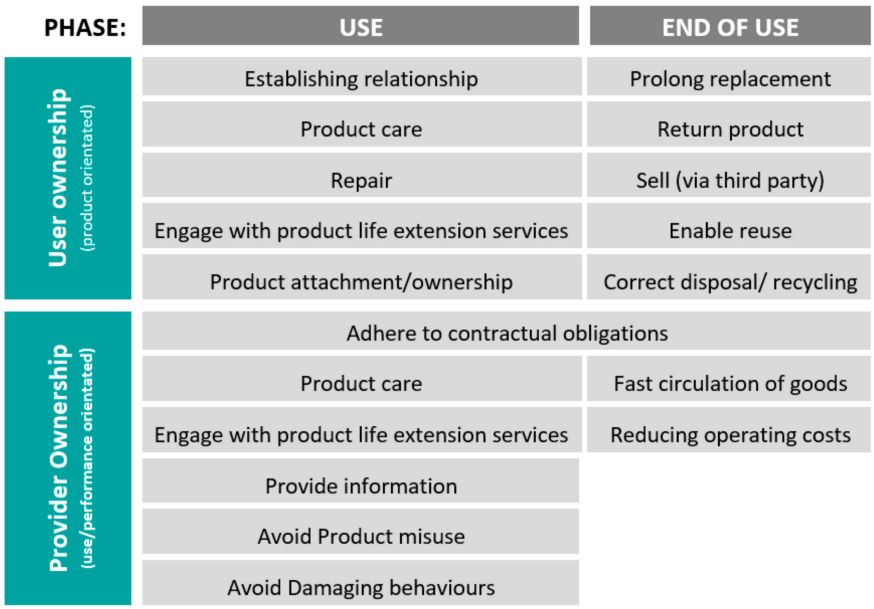

Figure 2. Model of Circular Behaviour: an outline of desired behaviours for circular business models.

6.1.1. User Ownership of Products

For products that are owned by users, a business or organisation generally has little control over what somebody does with a product when they have it. However there are still several ways in which organisations encourage desired circular behaviour.

During Use

Establishing a relationship involves registering a device with an original equipment manufacturer (OEM) or service provider, typically relevant when products are bought through a separate retailer. This allows businesses to engage with relevant after sales services, as well as informing users about any product issues. It may even allow businesses to plan end of life strategies.

Product care is an umbrella term, covering treating a product carefully, cleaning it or performing other preventative maintenance. Repair involves restoring a product back to a working condition and correcting any specific faults [17]. For these components, the user carries out both of these actions.

Alternatively, a user could *Engage with product life extension services*, using a service for general maintenance, repair or replacement parts. For example, Vitsoe provides services aimed at extending product life at nominal costs [44], the key thing is that customers use this service.

A number of authors have discussed design for *Product attachment and ownership* as a key circular design strategy [10,22,28]. Also known as emotionally durable design [65], the aim is for the user to form a strong relationship with the product meaning they take care of it, repair it if it breaks and postpone replacing it [19]. Work by Baxter et al. [41] suggests access over ownership business models

clash with this model of product attachment, suggesting it may not be suitable for other circular business models beyond long-life ownership of products.

End of Use

When a user owns an object, one way of extending its lifetime is to *prolong replacement*. This may be driven by product design strategies (design for repair, design for upgrade etc.) or a strong product attachment, but replacement behaviour can be driven by a vast range of factors such as consumer attitudes and situational influences [66].

One way for businesses to capture value from used products is if the customer *returns the product*, allowing the product, components or materials to be recirculated [20]. Ensuring the item stays as a whole working product means that it maintains its highest level of value [7,21]. Alternatively, users could *sell*, typically via a third-party site, such as eBay or through a second-hand store. Finally, users could *enable reuse* by giving used products to friends, family members or through platforms such as Freecycle or donating to charity.

Material recycling is the lowest level of preserving value in a circular economy [7], but in some product categories and circumstances it may be relevant. In these instances, *correct disposal/recycling* is necessary. This may involve separating materials for recycling, taking products to a designated recycling centre or in particular, not putting it in the general waste bin.

6.1.2. Provider Ownership

With products where the ownership is with the business or organisation, there is typically some form of agreement made, outlining what the relationship will be. This may define what is expected of the user and may also be supported by some kind of legal agreement. It is assumed that this defines that products must be returned to the service provider after a certain point. Therefore, the action of *adhering to contractual obligations* covers the act of returning products, along with behaviours such as keeping up with financial payments.

During Use

As with user ownership business models, *product care* is still relevant along with *engaging with product life extension services.* Less relevant, is that the user is required to make repairs to products themselves. However, it is not impossible that a user may be required to make repairs, for example MUD Jeans allows repairs on their leased jeans if the customer is based in more distant countries [67].

Providing information concerns informing the business on the state of the product. This may happen at the start of use, to ensure that the previous owner left it in a suitable condition, for example with car sharing schemes. It could also be during use, to flag up any concerns or early signs of damage or need for maintenance.

Two types of behaviours that should be avoided are *product misuse* and *damaging behaviours*. Product misuse is where the product is used for tasks, which it may not be designed for, such as shaving a pet with a beard trimmer, or washing football boots in the dishwasher. This may lead to product damage as well as other issues such as hygiene. Damaging behaviours, are ones which are destructive in nature and go beyond normal wear and tear. The key difference between product misuse and damage (or abuse) is intent, which may require different design strategies [58].

End of Use

In certain sharing services, to reduce the number of required products and maximise utilisation or sharing, it may be desirable that users of the service only have products for the exact time they are in use. This ensures that they are available for other users of the service. Behaviours contributing to this speeding up of sharing fall under *fast circulation of goods*. For example, Toronto Tool Library limits the time that users can keep tools, meaning users only take them out when they are needed and

therefore allow other users to access the tools, as well as reducing the amount of total tools needed to provide the service [68].

One of the barriers to circular business models is the capital required to cover running costs, such as managing a reverse logistics network [69], therefore it may also be desirable that user behaviour helps to *reduce these operating costs*. These behaviours may manifest themselves in many ways. An example could be assisting with reverse logistics, by taking used products to a post office rather than being collected. Another example could be ensuring products are returned clean or in a suitable condition for the following user. A real example of this can be seen by the headphone business Gerrard Street, where customers are sent a flat pack of parts, which then need to be assembled and disassembled when sent back [49]. This allows Gerrard Street to send their products in compact packages, which can fit through letterboxes, as well as reducing disassembly costs.

6.2. Business Strategies for Encouraging Behaviour

The case studies and interviews were further coded according to the Behaviour Change Wheel intervention functions [64], shown previously in Section 4.2.

All of the intervention functions were found through the case studies and interviews, apart from 'Modelling'. This may be because businesses felt that this strategy was not relevant in the context of the circular economy, but the sample size is too small to be definitive and this aspect requires further exploration. One strategy that cannot be categorised clearly which appeared a number of times was 'Trust'. 'Trust' between a customer and company can be crucial, for example, customers need to trust that by registering their details with a company they are not going to spammed with email marketing.

To inform actionable business strategies, these can be categorised according to the components of the business model; how a company creates, delivers and captures value [70]. The business model canvas, outlined by Osterwalder & Pigneur [70], is a tool to help visualise the key 'building blocks' of a business. In the case of circular business models, Lewandowski [9] proposed the addition of a Take-Back system component to the canvas. Table 4 provides a categorisation of the intervention functions found in the study and how they could be implemented as components of a business model. Other strategies that did not sit clearly in any business model component were rules regarding use (Restriction) and financial, or points based, Incentivisation or fines (Coercion).

Table 4. Examples of intervention functions categorised against Business model components from Osterwalder & Pigneur [70] and Lewandowski [9].

Business Model Component	Description	Related Intervention Functions	Examples
Value proposition	Products & services which create value for a customer	Incentivisation	IDEO's Optimax concept: customer gets personalised shoes designed from user data, in return for used shoes [71].
		Training	Patagonia is partnered with iFixit to explain to users how to repair their garments [72]
Customer relationships	The type of relationships a company has with its customers	Trust	Trust is key element for Vitsoe to build long lasting relationships with customers (Bocken & Short 2016), enabling them to provide services and maximise product lifetimes.
Channels	How a business communicates with and reaches customers	Education	Educating a customer on the actual value of used items
		Persuasion	Patagonia encourages customers to make repairs, reuse or recycle their products [44]
Take back system	Take back management system	Enablement	IDEO's Use Me/Loose Me concept, which makes reselling old appliances as effortless as possible [71].
		Environmental restructuring	Mud Jeans provides a repack and return to label to return old jeans after buying new ones [67].

7. Designing for Circular Behaviour (DfCB)

This section describes a process whereby products and aspects of a company's business models can be designed to help lead to the desired circular behaviours outlined in Section 6. The process is based

on three phases described by Daae et al. [61]; a user research phase, a design phase, where interventions are ideated, and a testing phase. In addition to the process outlined by Daae et al., aspects of the Behaviour Change Wheel [64] have been incorporated into the user research phase, which help link components of behaviour to the business strategies outlined previously. Figure 3 shows an overview of the DfCB process, outlining the three main phases and the activity involved at each stage. It is important to highlight that the process here is shown in a highly linear and stage-gate style, this is mainly for clarity of the key activities in each phase. In reality, the human-centred design process can be seen to seen through a number of 'spaces', is messy and highly iterative [73]. This next section will describe the key activities at each of these three stages of the process.

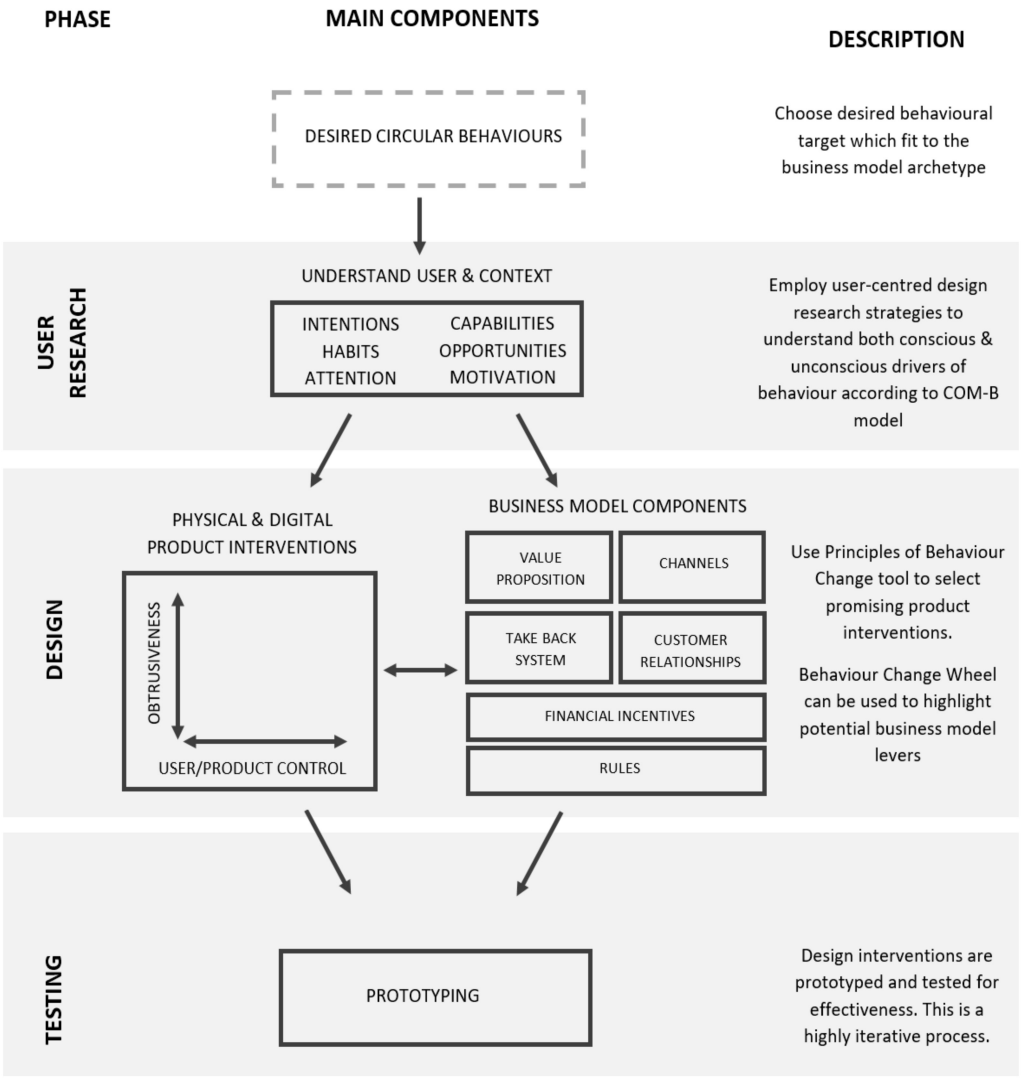

Figure 3. Outline of key components of Design for Circular Behaviour (DfCB) Process.

7.1. User Research

A number of authors researching DfBC advocate the need to take a Human-centred design (HCD) approach to thoroughly understand the user (for example; Wever et al. [33]; Bhamra et al. [36]; Wilson et al. [74]; Hanratty et al. [62]). In the user research phase, design research methods are used to understand the user and how they interact with the given product. In order to use the Principles of Behaviour Change tool, the main features to understand are the intentions of the user, any habitual behaviour and the attention required for certain actions [75]. To allow for a more in-depth

understanding, at this stage it is helpful to understand user behaviour according to the COM-B behavioural drivers outlined by Michie et al. [63]; Capability, Opportunity and Motivation.

In line with the COM-B model of behaviour, behaviour is driven by factors that are both internal (i.e., attitudes, values, habits and personal norms) or external (i.e., incentives, institutional constraints and social norms) [76,77]. The user may or may not be aware of these drivers of behaviour, meaning a range of research techniques may be needed to discover different aspects. Daae & Boks [77], provide a helpful classification of which design research is most focused to understanding internal/external and conscious/unconscious drivers. According to their classification, contextual enquiry and applied ethnography are the two research methods most suited to investigating the broad spectrum of behavioural drivers, including habits.

7.2. Design

The aim of the design phase is to develop product intervention strategies, as well as considering aspects of a business's business model, which can contribute to encouraging behaviour. These product and business strategies should not be designed in isolation, but rather developed to compliment and reinforce one another, as part of a whole system design approach [78]. As described in Section 4.1, product-led behaviour change interventions can be placed on two axis solutions space, with one axis describing the amount of control given to the user and the other axis describing the obtrusiveness of an intervention [61]. Based on the result of the user research phase, the Principles of Behaviour Change tool [61,79] can then be used to recommend suitable product strategies, dependent on the user's intentions, habits and the amount of attention required. These can be summarised as follows in Figure 4 [75].

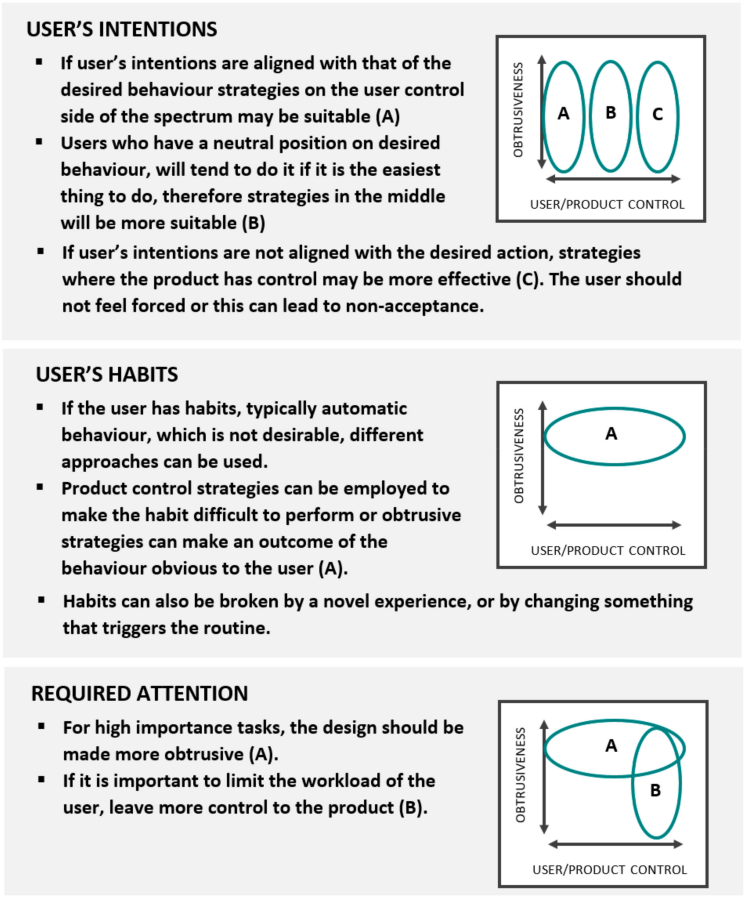

Figure 4. Summary of Principles of Behaviour Change tool, adapted from Zachrisson & Boks [79].

At this stage, it is also necessary to design the business model levers. These can be built directly from customer insights. However, through employing the COM-B model for understanding behaviour, the most promising intervention functions can be chosen, along with the business model components these can be delivered through. Figure 5 is based on work by Michie et al. [64], and shows which intervention functions are likely to be most effective for each COM-B component. It should be noted that 'Trust' as an intervention, as part of the Customer Relationships component, is not mapped against any behaviour components as it sits externally to the model, it should nonetheless be acknowledged and considered as a way of encouraging customer behaviour.

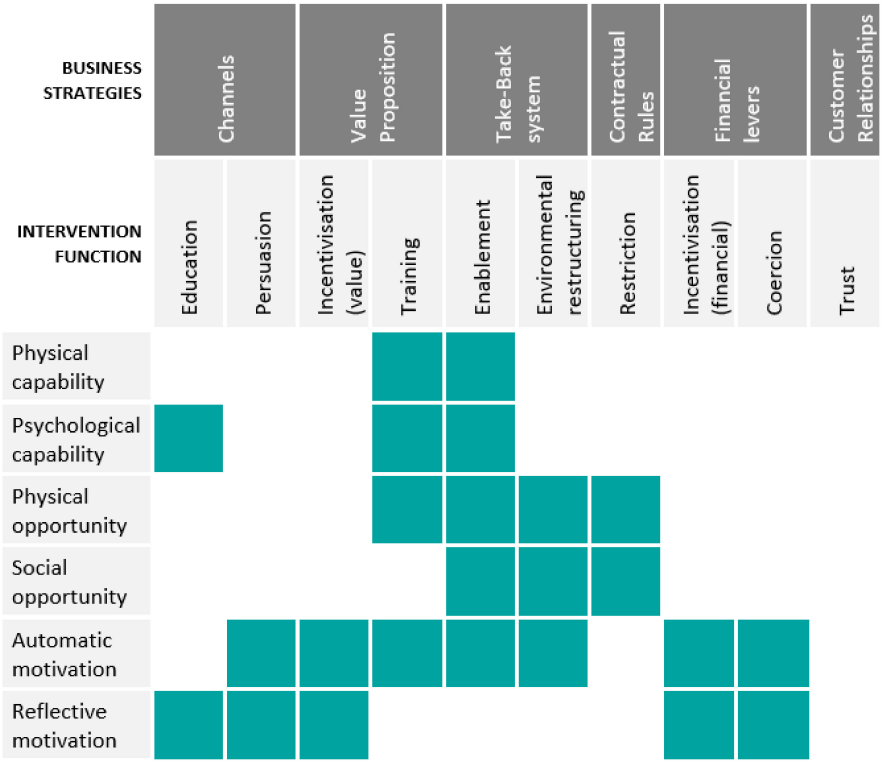

Figure 5. Links between COM-B and Intervention functions, adapted from [64].

7.3. Testing

Previous work in the field of DfSB has tended to focus on reducing specific measurable outputs, such as energy usage [80] or measured emissions [61]. This level of quantitative measuring of an output is not as relevant in this circular economy context. Instead, interventions should be evaluated against how effective the function is in changing the behaviour found through the contextual research study [74]. This involves cyclically designing, prototyping and testing, first at a low fidelity level, eventually moving to higher fidelity prototypes to measure actual metrics of success [81]. This applies to both product and business model interventions.

8. Discussion

The model of circular behaviour proposed in this paper outlines the main behavioural targets to consider when designing product or business solutions for a circular economy. Some will not be relevant in every case and what is desirable will vary based on several factors, including, the product category, its cost, where it goes after use (directly to another user or back to the service provider) or the speed in which it is circulated. As described in Section 2, circular design strategies to date have tended to focus on physical product design elements. This framework helps to encompass more of the human aspects into the field of circular design. The design for circular behaviour process offers designers

a structured way to think about behaviour and can help enable them to consider how product strategies can shape this user role, as well as highlighting potential areas of leverage in the wider business model. There are, however, some matters which require further discussion and consideration.

The DfCB process was developed based on behaviour change literature and informed by interviews with circular economy practitioners. It incorporates two different design for behaviour change methods, Principles of Behaviour Change by Zachrisson & Boks [79] and the Behaviour Change Wheel by Michie et al. [63,64]. Although both methods have been tested and applied individually in different contexts, the process brings these two together and introduces other novel elements, such as the business model strategies. It is therefore currently theoretical and should be viewed as a preliminary model until it has been tested in a practical application. It may also be the case that certain behaviour categories, particularly ones that do not involve specific actions, such as product attachment, are less suited to using the principles of the process outlined here. However, the model of desired circular behaviour can also act as a standalone tool for designers to use when considering new circular product and service ideas.

The employment of design for behaviour change strategies raises a number of questions. The first is whether aiming to change consumer behaviour is relevant in the circular economy at all. Different authors have taken different positions on this point. Piscicelli et al. [25] advocate that DfBC strategies should be explored to increase acceptance of circular PSS. Moreno et al. [28] argued against this, stating that by taking a more systems thinking approach, designers can produce offerings which are more accepted. Moreno et al. [28] go further in stating that DfBC is not needed as a circular design strategy; if a holistic approach is taken for balancing user needs within a circular model, there is no need to for the user to behave in a more sustainable way. In fact, neither of these arguments are relevant to this piece of research. Firstly, the issue of consumer acceptance of new business models or motives for purchasing products is outside the scope of this work and therefore this paper explores a different application of DfBC as suggested by Piscicelli et al. [25]. Secondly, as mentioned in Section 1, DfCB is quite distinct from previous applications of DfSB, which has mainly focused on reducing energy use or environmental impacts at an individual level.

A related question to ask is whether DfBC strategies are the correct route to create this change in consumer behaviour. Arguing in favour of practice theory, Kuijer & Bakker [82] highlight a number of key concerns with DfBC approaches, in particular design for sustainable behaviour. The most relevant of these concerns in this context are:

- There is a risk of failing to achieve the intended behaviour change by focusing on specific use scenarios.
- There is a risk of missing opportunities of larger scales of change by focusing too much on the scale of the individual level.

Deconstructing these points separately, the first argument that DfSB tends to focus on specific use scenarios, is important and should be avoided. This can be done by focusing on the user's more general motives (beyond specific actions), as well as considering wider behavioural drivers as part of the COM-B model. The second argument is most relevant. To give a circular economy example, would focusing too much on ensuring users look after DVDs miss out the wider opportunity of shifting to a virtualised and more circular service such as Netflix? Potentially yes, but this goes back to the point that DfBC should not be viewed as the driver of systemic change, but a single strategy in helping bring about this change.

As discussed by Piscicelli & Ludden [25] (and highlighted in Section 1), the current discussion on transitioning to a circular economy has tended to underestimate the role of the user, mainly because the circular economy is viewed as a producer-led solution [83]. This paper is not seeking to challenge that the shift to a circular economy should be producer-led, but highlights how customer behaviour does have an impact and that it should be considered and designed for where relevant.

An interesting and important point to mention is the changing aspect of ownership in the circular economy and how this could have profound effects on consumer rights and experience. Within the

circular economy vision, companies have a heightened interest in the products they make and what happens to them after they have been used. Business models will be increasingly built around circulating products and therefore designing restorative systems around them, often as part of PSS. As more firms move towards these type of models, user behaviour will inevitably become increasingly of interest. This relationship may be exacerbated by the ability to track and monitor assets at all times through connected devices. As described by Webster: '*In some real sense ownership implies rights to determine what a person's relationship is with products and property, to have right to use, abuse, abandon or dispose*' [84] p. 139, in moving to an access over ownership economy, what sense of this personal control over products and behaviour could be lost? The ethics around DFBC have been discussed at length by other authors (for example Lilley & Wilson [85] and Niederer et al. [53]) and these discussions will be of continuous relevance due to businesses having further reason to move into the area of behaviour change.

Finally, although a range of research methods were used in this study, there are some limitations with the approach. Only eight case studies were explored, which is a relatively small number. The reason for this was down to two factors. The first is that it is acknowledged that there has been limited progression of circular business models in a B2C domain [86], hence making it difficult to find strong case study examples. This is linked to the second factor, that case studies were only taken from the Ellen MacArthur Foundation case archives, or ones which were referenced in other literature, to ensure they were sufficiently circular in nature. Again, limiting the possible number. To help overcome this, circular economy practitioners were interviewed to provide a more in-depth understanding, as well as refining and validating the framework. Despite the combination of research methods, the model of circular behaviour is not exhaustive, but instead aims to highlight what is most prominent.

9. Conclusions

This paper has sought to help address a gap in current circular design literature, which tends to focus more on physical design characteristics, while arguably overlooking customer and user influences on circularity. The two aims of this work were: to describe what user behaviour is required to help circular business models to function and create a framework for designing products and services to encourage desired circular behaviours. To address these aims, three research strands were completed, leading to the development of the design for circular behaviour framework. Firstly, the model of circular behaviour provides a description of desired circular behaviours and categorises them according to whether ownership of the product is with the user or service provider. While this study does not offer a conclusive answer to the question of the role of the user in a circular economy, it does provide a starting point for further discussion and development of a shared terminology. Secondly, the design for circular behaviour process has been developed to help describe how to encourage these desired behaviours through a company's products and business model.

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Appendix A

Table A1. Coding examples of desired circular behaviour.

	Code	Case Study Example/Interview Quote
Product-based business models	Use repair service	'just keep tapping in to the (service) network, keep using it, the product and the service'
	Self-repair	Patagonia encourages and enables customers to make repairs to their clothing [72].
	Product care	'They may need to do maintaining behaviours, such as cleaning the hair, or descaling it. Keep products up and running in their top form. Small day to day things that users can do to stop issues from happening.'
	Enable reuse	The Optimist toaster concept from The Agency of Design is designed to be passed down through the generations [87]
	Sell	'we encourage the Ebay market—we absolutely encourage that market'
	Send back to manufacturer	With IDEO's Optimax concept, the user returns the whole trainer after use [71].
	Send parts back	'if we are predicting that a product has particular issues, or needs a tweaking or parts swap, it's great if they comply and play a restorative role'
	Not disposing of products	'sadly with a lot of these products, they will just go in the bin because it's the easiest option'
	Prolonging disposal	Vitsoe aims to avoid the customer cycle of replacement and repurchasing through offering product-life prolonging services at nominal cost [44]
	Suitable recycling	'for recycling—having the user do more suitable end of life things like disassembling, separating materials- that could also be a desirable user behaviour'
	Establishing relationship	'establishing a relationship between the customer and the manufacturer, and understanding why that might bring value for them'
	Increase use phase	'we need to slow the consumption down, that's one of the problems for the circular economy—there's so much volume'
	Not forgetting products	'products that customers already own might have low worth in their mind and that's a challenge. Unused products are very back of mind.'
Access/performance based model	Communal care	'being a good user for the next person'
	Product specific care	Toronto Tool Library asks service users not to overcharge the batteries of their tools [68].
	Return in good condition	'you could ask them to get involved to make all of our end of life processes easier—to have less cost associated with acquiring the inputs for a second cycle'
	Reducing operational cost	'The last mile is expensive. Being prepared to pick up stuff and return stuff to a local pick up point'
	Keep product for long time	Bundles uses a deposit mechanism to encourage customers to keep product for a long time.
	Not forgetting about product	'worth of products that customers already own have low worth in their mind and that's a challenge. Unused products are very back of mind.'
	Swapping broken parts	Gerrard Street requires users to return parts of the headphones which break [88]
	Non-damaging behaviours	'Not break products—not doing destructive behaviours'
	Product misuse	'We need them to use it in the intended way—for example, using beard trimmer for shaving their cat. This type of behaviour can break a product and can be unhygienic'
	Contractual obligations	'financial behaviours for monthly paying, not defaulting on a payment'

Appendix B

Table A2. Coding examples of strategies for encouraging behaviour.

Code (Intervention Function)	Case Study Example/Interview Quote
Incentivisation (financial)	'help them pass it onto a good cause and maybe get a bit of income from it'
Incentivisation (providing value)	'a circular model can help meet that need (of closure) if you're handing something back, you have that closure' 'with the shoe, the value was data, so there is an incentive for you to return it'
Training	Patagonia is partnered with iFixit to explain to users how to repair their garments (iFixit 2017)
Education	'education, education, education . . . that's what we are doing, day in, day out'
Persuasion	'Persuading them that spending a little more on day one will actually cost them less in the long run'
Enablement	'making it as convenient as possible' 'customers want the most convenient way to get things out of their house'
Environmental restructuring	Mud Jeans provides a repack and return to label to send them old jean after buying new ones (MUD Jeans 2017)
Trust	'need to try get trust and an attachment to a service'

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